INSURANCE AS AN INSTRUMENT OF RISK MANAGEMENT IN LOGISTICS SYSTEMS

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Abstract: Logistics systems, like other business systems, are characterised by a large number of risks changing often in place and time. Risk management in supply chain and logistics involves identification of possible threats to the system or process, undertaking measures with the aim to reduce the possibility of their realisation and minimize any loss events in case those threats are nevertheless realised. The aim of risk management is to set up optimal control over the identified risks, which results in more stable systems, reduction in cancelled operations or failures in operations and maximising system reliability, effectiveness and profitability. One of the instruments of risk management in logistics systems is insurance. The most frequent line of insurance used for coverage of risks in logistics systems or processes is transportation insurance, including wide range of different types and subtypes within this insurance line. Insurance can cover the risks that business and logistics systems are always exposed to in those situations when their in-house management is not cost-effective. In insurance practise, it is often difficult to assess the amount of risk related to logistics systems and processes and to determine premium rate of insurance. A number of statistical methods, as well as mathematical and actuarial models, are used in the process of assessing risk of any particular insurance coverage.

Keywords: Logistic, transport, risk, insurance, utility.

1. Introduction

Risk management is a process of making decisions on acceptance of known or assessed risks and/or implementation of actions in order to reduce consequences or probability of their occurrence. The objective of response to an identified risk in the logistic system is to find and apply adequate risk control method. The most common problems in practice are inefficient, poorly established or a non-systematic risk control process. That often leads to increased probability of realisation of unwanted effects, i.e. increase of total risk of the system's business operations. There are various risk management methods, whose complexity can be in interval of very simple to extremely complex ones, and their implementation depends on the size of the observed logistic system, available information, available time for analysis, implementation costs, human resources, numerous limitations, etc. Transportation insurance is a very efficient instrument for risk management of logistics systems. In the world practice, various terminology related to transport insurance, logistics and supply chains is used as the widest term (Seltmann, 2004). In certain cases, the insurance can only partially cover the damage that complex supply chains and logistics systems may suffer, because the damage and costs incurred by the interruption of the continuity of the logistics processes can be significantly higher than individual or aggregate claims that may be covered by insurance.

According to Mau and Mau (2009), there is a positive correlation between the reliability of supply chains or logistics systems and risk management, in case of usual, standard risk management activities. However, when the applied level of management significantly increased, the level of reliability is generally not increased in proportion to the costs, which most often grow rapidly. In addition, in the majority of cases in the logistics systems practice it is impossible to achieve absolute reliability, that is, there is always an area of unreliability. For this reason, as part of possible activities of logistics systems towards minimization of risk, the role of the insurance institution appears. The risk assessment includes the assessment of individual impacts of all known risk elements (including major risk events, indirect events, causes of events, different constraints, etc.), as well as the overall risk assessment, i.e. the reliability of the entire system (including the duration of the risk, the direct and indirect consequences, spatial scope, etc.).

Implementation of actuarial principles in transportation insurance is often limited by the fact that this insurance covers an almost unlimited set of different insurance items, a large number of different circumstances characterized by specific logistic processes, with the fact that there is permanent market variability, seasonal effects on risk and many other factors. In transportation insurance, risk quantification is often done without the use of exact mathematics, statistics and different models, but based on intuition, experience and knowledge of risks.

2. Credibility, Vagueness and a Lack of Data Necessary for Risk Assessment

Actuarial scope in insurance implies the application of actuarial and mathematical methods, models and techniques in order to examine the phenomena, facts and unforeseen circumstances faced by the insurer, as well as to neutralize the financial effects of those circumstances on the insurer. One of the most important activities of insurers in the function of providing adequate insurance coverage is the segment of underwriting in insurance. Underwriting involves the process of analyzing, selecting and classifying the insurance claims, assessing the exposure of potential clients to certain risks, and determining the terms and prices of the insurance cover (Macedo, 2009; Klen, 2004.). The main role of an

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underwriter is to ensure profitable insurance portfolio, i.e. that ratio between earned insurance premium and paid claims is on the level of projected objective.
There are six prerequisites for accepting insurance risks, which are considered ideal for an insurer (addapted, Rejda, 2008):

- Extensive number of risk exposures in the past;
- Claims must be accidental and unintentional;
- Claims must be determined and measurable;
- Claims should not be catastrophic;
- Claims probability and the consequences of damages should be calculated;
- The insurance premium must be economically acceptable.

In practice, insurers are exposed to a large number of risks that do not meet criteria of an ideal risk. For this reason, insurance business is followed by uncertainty, ambiguity, vagueness and errors in the process of acceptance of risk. Having in mind that any natural person or a legal entity has an objective to maximise the expected utility of its assets, whose value is assumed to be subject to changes under influence of various deterministic and accidental factors, a criterion is defined for maximisation of expected utility (EUM - Expected utility maximization). In this paper, we illustrated EUM application to insurance from the aspect of the insured and the insurer. As common attribute of all insurers is risk aversion, functions are defined as a risk aversion measure from the aspect of persons whose goal is maximizing the expected utility of capital. Considering the main property of the EUM criteria – linearity, it is shown that this property is not always adequate to describe the preference of individuals. Allais's paradox was presented, as a motivation for the introduction of different approaches to describe the preferences of individuals. They represent the generalization based on EUM criteria.
Many insurance contracts are contingent on rare events such as different rare events, unknown risks, disasters, terrorist activities, political risks etc. whose probabilities are not known with precision. Such insurances are said to be subject to term ambiguity (Kunreuther et al., 1995; Viscusi, 1993). This term also applies to some lines of transportation insurance. There is by now a body of evidence to show that, faced with offering an insurance contract under ambiguity, insurers increase their premiums, reduce limit coverage, or are unwilling to provide insurance at all. In the practice of insurance, actuaries and underwriters from insurance and reinsurance companies are asked to quote prices for hypothetical contracts in which the probabilities and consequences of loss are relative known or unknown.
There is plenty of evidence based on experiments indicating that individuals treat unknown probabilities differently from the probabilities that are well predicted. Ellsberg's classic work (1961) found that, for events involving profit, individuals prefer a lottery with well-predicted probabilities compared to those with unknown probabilities, unless the chances of winning are small. A number of experiments confirmed the Ellsberg hypothesis.
The insurer can influence a certain number of risks, implementing the principles and tenets of modern business. However, there are numerous risks beyond the influence of insurers as well as the risks with the limited impact. For this reason, the insurance company must implement a systematic approach to managing risks, using modern actuarial, financial, legal, technical and other mechanisms, in order to protect itself as well as to protect its clients. Characteristics of the risks inherent in the logistics systems and processes predetermine the nature and modalities of insurance. Considering the number of entities and the complexity of supply chains and logistics systems, the existence of a multitude subsystems and relationships between entities, in practice, a large number of different nonlife insurance is applied as a risk management instrument.
Table 1 shows the most important types of insurance exist in supply chains and logistics and entities that need insurance:

Table 1
Nonlife insurance in supply chains and logistics

Importer/carrier - Goods in transit insurance (Marine cargo insurance) - Liability insurance - Insurance of customs debt	**Enterprise** - Property insurance - Employees' insurance - Liability insurance for loss/keeping of goods	**Forwarding agent** - Professional liability insurance - Goods liability insurance - Warehouse operator's liability - Insurance of forwarding agent's interest - Goods in transit insurance (transferrable)
Consolidator of goods - Liability insurance for accuracy of transportation and storage documents regarding goods in transit	**Liability of employees in ports and terminals** - Accident insurance for employees - Liability insurance for employees in ports and terminals	**Maritime or river carrier** - Insurance of vessels and liability - Third-party liability insurance - Liability insurance according to rules of P&I Clubs - Goods in transit insurance

	- Property insurance and general liability	(transferrable)
Customs authorities - Receivables insurance - Credit insurance - Guarantee insurance	**Liability of ports and terminals** - Liability insurance of ports and terminals - Warehouse operator's liability - Property insurance and general liability	**Road or rail carriers** - Road and rail carriers' liability for goods - Insurance of carrier's interest - Goods in transit insurance (transferrable) - Third-party liability insurance

Source: adapted, Brown et al.*, 2012*

In practice, underwriters' decisions are usualy made based on individual risk perception, especially in transportation insurance. For the insurer it is very important to obtain complete and accurate information for assessing the level of risk of insurance coverages. However, there is a situation in practice where insureds deliberately select information or provide false information on the level of internal or external risks that is in insurance called anti-selection (adverse selection) (Werner and Modlin, 2010; Rejda, 2008), which is present in transportation insurance lines. Anti-selection is very unfavorable for insurance companies and is seen as one segment of operational risk in insurance. In transportation insurance, expert assessment of riskiness of certain risk elements of the observed logistic process is often performed in order to review the total risk, based on which the premium rate or insurance premium is determined. Definition of insurance contract elements and evaluation of the premium rate include expert consideration of influence of numerous factors, including potential initial risky events, indirect events, causes of events, modalities of various influences, and the like. If underwritters and actuaries regularly determine higher premium rates than real ones due to inadequate expert judgment of risk parameters, this can contribute to a reduction in the demand for insurance and lead to market failure of the insurer and miscarriage to perform the expected profit from the activity. On the contrary, contracting of premium rates lower than the actual ones generates risks of inability to fulfil obligations from an insurance contract, insured's interests are impaired, insurer's business reputation is lost, etc., and in certain cases there are risks of impairment of insurer's liquidity and solvency. Numerous problems related to decision-making are characterized in insurance, especially transportation insurance. In practice, it is often that different underwriters have different perceptions about the risk of the same or similar insurance coverage, also, inconsistancy in underwriters' information in process of risk assessment modeling.

3. Expected Utility Theory

The Utility theory is widely used in the field of risk management and insurance because the behaviour of the decision maker regarding risk level and its acceptability is described in accordance with the individual significance of money. From the aspect of the insurer, the policyholder often decides to pay a premium that is higher than the expected amount of loss based on the Utility theory (Trownbridge, 1989; McClenahan, 2001, 2004; Brown and Gottilieb, 2001; Kaas et al., 2009; Daykin et al., 1995). The above problem is mathematically formalized using the appropriate utility function and utility curve for the purpose of a more realistic and accurate presentation of the value of money. The individual's risk attitude, within the expected utility theory, is determined by the shape of the utility function that is presumed to be his choice. The utility function is concave for an individual who is risk-averse, convex for the risk-seeking individual, while for the risk-neutral person utility function is linear. However, while economic theory and practice suggest that individuals under conditions of uncertainty do not behave in accordance with the basic principles of conventional theory, there is no new unified and universally accepted theory that would be compatible with all the previous knowledge about the choice of an individual under uncertan conditions. Violation of the axiom of uncertainty led to development of Machina's generalized expected utility analysis and Chew-MacCrimmon theory. The most common alternative to the expected utility theory is the prospect theory. According to this theory, a loss has a greater value in the absolute value than the profit of the same value, so in case of losses a decision-maker strives to take risks, while in case of profit strives to avoid risks.

Bernoulli assumed that the utility of capital x, can be measured by a function $u(x)$ which, in general, is not linear, and proposed a utility function $u(x)=\ln x.$ He introduced the assumption that the increase in utility is proportional to the relative change in capital, or if the capital x increases by dx, then the increase in utility $du(x)$ is proportional to $\frac{dx}{x}$, for $du=k\frac{dx}{x}, k=\text{constant}.$ By solving the differential equation we obtain $u(x)=k\ln x+C, C=\text{constant}.$

In the modern form, Expected Utility Theory was developed by Neumann and Morgenstern (1947). They have shown that an individual whose preferences satisfy certain axioms (ordering, continuity, and invariance), under uncertain conditions, will choose between alternatives in order to maximize the expected utility associated with the possible results of his choice. Individual preferences are defined through a set of all possible alternatives. Let Q and R be any two possible alternatives that belong to a set of possible alternatives and probabilities $p \in [0,1]$. The third alternative from a set of possible alternatives is a combination of the previous two, Q has probability p, and probability of R is $(1-p)$.

Axiom 1. (Ordering). The axiom involves completeness and transitivity.

Completeness means that when choosing between the alternatives q and r it must know exactly which alternative is preferred or that both alternatives are equally attractive.

Transitivity means that if Q is preferable to R and R is preferable to S, then Q is preferable in relation to S.

Axiom 2. (Continuity). Let Q, R, and S be any three alternatives, Q> R> S. Then, there must be a complex alternative composed of Q and S with the probability p and $(1-p)$, that will be indifferent with respect to R. Axiom explains existence of the alternative that is unlimitedly better or worse than other alternatives.

Axiom 3. (Independence or linear probability). Let Q, R, and S be any three alternatives such that Q ≥ R. Then p: (1 - *p*), the compound probability of the alternatives Q and S must be slightly preferable with respect to $p:(1-p)$, compound probability alternative R and S.

If u is a utility function, defined on a real interval, and X and Y random variables, then

$X \succcurlyeq Y \Leftrightarrow E\{u(X)\} \geq E\{u(Y)\}$.

The relation $\succcurlyeq$ is called preference relation. Specially, it is $X \simeq Y$, when random variables have the same expected utility. The function u can be defined to linear transformation, which enables scale adjustment that measures the utility. In this way, it is also permissible that the function u takes negative values.

Let random variables be defined on the probability space (Ω, $\mathscr{F}$, P). Preference relation on set $\mathscr{F}$ is defined as $FX \succcurlyeq FY \Leftrightarrow X \succcurlyeq Y$. In this way, preference relation is defined over the class $\mathcal{X}$ of random variables, and distribution functions from set $\mathscr{F}$.

For a fixed utility function, let

$$U(F) = \int_{-\infty}^{\infty} u(x)\,dF(x)$$

ultimate for each $F \in \mathscr{F}$. Then $U(F)$ is called utility functional.

Let F_1 and F_2 are distribution function and $p \in [0,1]$. Function $F^{(p)}$ is called the mixed distribution F_1 and F_2, if

$F^{p}(x) = pF_1(x) + (1-p)F_2(x), \quad x \in R.$

The main characteristic of expected utility maximization criterion is

$U\left(pF_1(x) + (1-p)F_2(x)\right) = pU\left(F_1(x)\right) + (1-p)U\left(F_2(x)\right),$

which means U is linear functional.

Let X be a random variable that presents the capital of the insurer. In this case, the utility of capital $u(X)$ is also a random variable, so the expected utility of capital is further considered as $E\{u(X)\}$. The expected utility of capital is completely determined by the distribution function of the random variable X. In that sense, it is sufficient to consider the relation of preference $\succcurlyeq$ to the set of distribution F. There is a great number of evidence that point to the fact that individuals' behaviour under uncertainty conditions is not in accordance with the independence axiom. Allais paradox was of great importance for development of more general criteria. Accidental profits are observed X_1, X_2, X_3 *i* X_4 with values $x \in \{0, 10\text{M}, 30\text{M}\}$ and corresponding probabilities:

Table 2

Example of the Allais paradox

	0$	10M$	30M$
F_1	0	1	0
F_2	0.01	0.89	0.1
F_3	0.9	0	0.1
F_4	0.89	0.11	0

Most people will prefer to earn X_1 in relation to X_2 because of belief that it's better to get 10M $ guaranteed rather than the posibility to gain $ 30M with the risk of not getting anything, so $F_1 \succ F_2$.

If we observe the income X_3 and X_4, the probability of not getting anything is high and approximate. A person who chooses between such income is ready to lose, so he chooses an option that allows a higher potential gain, so $F_3 \succ F_4$.

Mixed distributions are observed $\frac{1}{2}F_1+\frac{1}{2}F_3$ and $\frac{1}{2}F_2+\frac{1}{2}F_4$. If preference relation $\succ$ is defined according to utility functional, then, based on linearity is $\frac{1}{2}F_1+\frac{1}{2}F_3 \succ 1$.

On the other hand, a direct calculation presents $\frac{1}{2}F_1+\frac{1}{2}F_3 = \frac{1}{2}F_2+\frac{1}{2}F_4$.

Therefore, linearity of the utility functional that is characteristic for EUM approach led to a conclusion that is contradictory to results obtained by a direct calculation.

EUM criteria can be used to determine the insurance premium acceptable for insurer. Let's mark with ξ the insured's loss, which the insurer takes as a substitute for the premium H. The insurer with the utility function $u_1(x)$ and insurance reserve w_1 wishes to maximise utility of its capital. Pursuant to the principle of expected utility maximisation, the acceptable premium for the insurer H, must satisfy inequality $u_1(w_1) \le E\{u_1(w_1+H-\xi)\}$, so for the minimum acceptable premium *Hmin* is valid $u_1(w_1) = E\{u_1(w_1+H_{\min}-\xi)\}$

The insurer finds acceptable the insurance premium that guarantees that the expected utility of its capital, in case of writing of and insurance contract, would be at least on the level of utility of its initial capital.

The experimental literature has proved the robustness of ambiguity reaction under different experimental conditions but while the issue of comparing individual valuations under known probabilities (risk) versus unknown probabilities (ambiguity) has been dealt with in several papers, little attention has been devoted to the analysis of the effect that alternative representations of ambiguity may have on individuals' reaction to uncertainty. We will consider this from the insurance underwriters' point of view.

According to the expected utility theory, an underwriter that prefers a certain outcome will charge higher premium, while loss variance around given medium value is increased (Goovaerts and Taylor, 1987). In the context of this study, we can analyse two risks. For risk no. 1 experts estimate a probability p of the known loss L. Let r_1 be premium collected for full insurance of this risk. For risk no. 2 probability of occurrence of this event is still p, but potential loss is uncertain, although experts estimated that it is limited L_{min} and L_{max} (usual limit of loss per written insurance policy). The resulting insurance premium (i.e. premium is such that the underwriter does not care whether to insure this risk or not), r_2, is defined by (Kunreuther et al, 1995).

$$U(A) = p\sum_{i=L_{\min}}^{L_{\max}} q_i U(A-L_i+r_2)+(1-p)U(A+r_2)$$

where q_i is probability that the insured loss would be L_i, A is insurer's assets, and U is the utility function of the underwriter. Let's assume that the expected value of loss in this distribution would be the same as the known loss L. In this case, premium r_2 will be higher than r_1 for underwriters who prefer a certain outcome.

If we consider a situation with ambiguity or uncertainty about probability of occurrence of the said event, we can assume that that the underwriter has k various experts' opinions about probability of the stated loss in the stated time. Let experts' evaluations on probability be marked as p_i, i = 1...k. Underwriter's best forecast on probability of loss occurrence is an estimate by one number, p = f (p_1...p_k).

Expected utility theory means that when insuring a single risk, ambiguity should not affect the premium charged by the underwriter if the underwriter believes the experts' estimates (Hogarth and Kunreuther, 1989). In order to show this, we will define that r_3 is premium when the probability is ambiguous with the best approximation, $p^* = f(p_1...p_k)$, and the loss varies between L_{min} and L_{max}. In order to operationalize p*, let's assume that n experts disagree and that linear weigh rule is used for combining their various estimates of probability. All other procedures for the same estimate p*, for an uncertain probability, will lead to the same qualitative forecast (Hogarth and Kunreuther, 1992).

4. Conclusion

In transportation insurance, many risk elements influence the overall risk level, independently or in interaction with each other. Considering the number of risks in transport, it is very difficult to simultaneously analyze and evaluate all risk elements, especially with a high degree of reliability. It is often impossible or very difficult to make clear delineations between identified risk elements, which can be classified according to various criteria. In addition, certain elements and sub-elements of risk lead to the total or partial exclusion of others, while certain elements and sub-elements are not even included, due to their number and assumption of their minor importance. Insurance premiums are generally determined by actuaries and underwriters, based on experience and available statistical data on earned premium, claims, costs, etc. Provision of required numbers of statistical data on homogenous groups of subject matters of insurance can be a big problem. Utility theory solves numerous issues in the area of risk acceptance in insurance, uncertainty, imprecise decision-making and the like, due to many influences and limits on one side, and lack of representative data on the other side. Expected value of a certain loss observed as a stochastic category can be used as a measure for risk level or an instrument for comparison of various alternatives regarding risks; however, this value does not always present a real criterion. Potential clients in insurance often do not accept the expected values principle, but base their decisions on financial standings and readiness to independently accept and carry the risk. Utility theory is to a great extent applied in risk management and in transportation insurance because the decision-maker's behaviour on the risk level and its acceptability is described realistically, taking into account certain subjective factors regarding individual meaning of money.

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